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Studies on 0.45 GeV/n Kr collisions using solid state nuclear track detectors

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Abstract A search has been made on the inelastic collision of 0.45 GeV/n $^{84}_{36}$Kr ions in Hungarian brand Cr39 (MA-ND) track detector. The charge response of the polymer detector has been studied to investigate the nuclear fragmentation phenomena. The exposed track detectors were etched for 20 hours in 6N NaOH solution at 70°C and the etch pits were measured using a Leitz optical microscope. The present results have been compared with the earlier short hour etched results. The charge resolution of the detector has been calculated but no remarkable change is observed from the results as expected from long hour etching of the track detector. The charge response of the detector shows an exponential fall with the increase of etching time.

Keywords 0.45 GeV/n Kr, charge response, projectile fragmentation

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1. Introduction

Detection of cosmic nuclei in high altitude balloon flights and in satellite exposures are very much simplified with the plastic detectors. CR39 is such a solid state nuclear track detector (SSNTD) which is widely used in space exposures, specially because of its high detection sensitivity [1, 2] above $Z/\beta \geq 6$, and light weight. Moreover, unlike emulsion, it can keep latent tracks for years without fading. For the calibration of these SSNTDs', laboratory exposures have been done where relativistic ion beams from accelerators are made to fall at differen

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incident angles on these detectors. Ahlen *et al.* [3] have studied response and charge resolution of 1.45 GeV/n $^{84}_{36}$Kr using CR39 (DOP) which was manufactured by Pershore Mouldings, England. Later Salamon *et al.* [4] have also reported the charge resolution of CR39 detector exposed to 1.45A GeV $^{84}_{36}$Kr ions and compared them with theoretical results. Earlier, we [5] have studied the projectile fragmentation of 0.45 GeV/n $^{84}_{36}$Kr on Hungarian brand CR39 (MA-ND).

The charge resolution of this CR39 (MA-ND) detector for charges ranging from Z = 25 to 36 has been compared [5] with the theoretical results after Salamon *et al* [4]. We have also studied a systematic variation of diameter, cone length and charge resolution with increasing etching time (4, 6, 8 and 12 hours) from the interaction of 0.45A GeV $^{84}_{36}$Kr on CR39 (MA-ND) [6]. In the present paper we have added our observations for 20 hours etching which seems to yield more concluding nature of the etching time dependence of charge resolution and charge response CR39 (MA-ND).

2. Experiment

A stack of CR39 (MA-ND) of dimension (5.5 × 2 × 5) cm^3 has been exposed to 0.45 GeV /n $^{84}_{36}$Kr beam at an angle of 30° from LBL BEVALAC. One of the detector sheets has been etched in 6N NaOH solution at 70°C for 20 hours to enlarge the etch pits for easy and accurate scanning. We have taken the $^{84}_{36}$Kr and its projectile fragments only and thus obtained 636 events in the above mentioned area. The estimated bulk etch rate is 1.2 μm/hr. The pits obtained are of elliptical shaped and we have taken the two surface average of the four measurable parameters *viz.* major axis (a), minor axis (b), surface projection of the cone tip (s) and depth of the cone tip

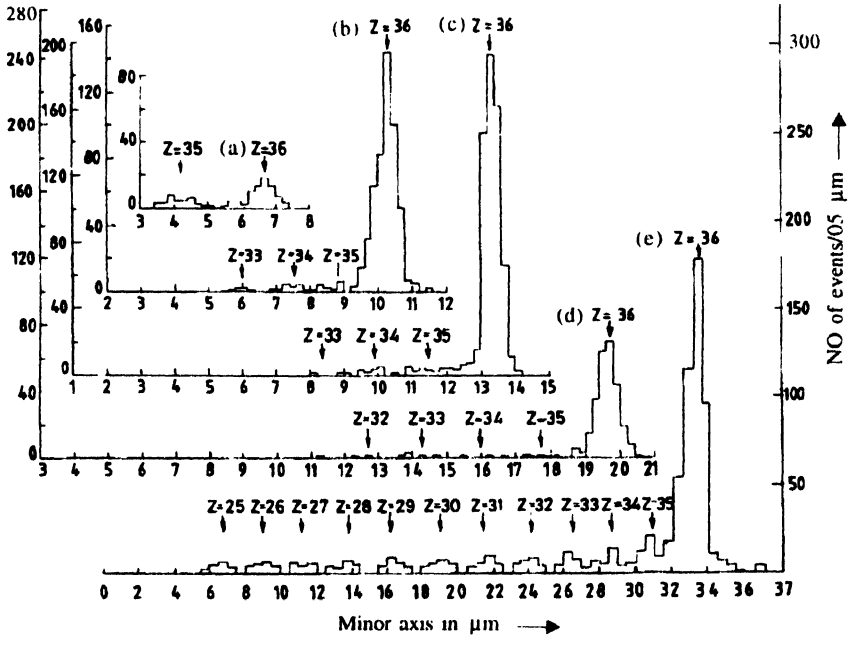

Figure 1. The etch pit diameter distribution of 0.45A GeV projectile $^{84}_{36}$Kr fragments produced in CR39 (MA-ND) target obtained from the scanned track detector etched for different etching times (a) for 4 h, (b) for 6 h, (c) for 8 h, (d) for 12 h and (e) for 20 h, respectively.

(z). The measurements are done under a × 40 objective and a × 15 filar micrometer eyepiece of a Leitz Ortholux Microscope. The least count of this objective-eyepiece combination was 0.2μm.

3. Result and discussion

The diameter distribution of the optically measured elliptic etch pits those which are obtained after 20 hours of etching are displayed in Figure 1 along with the diameter distribution obtained for previous short hour etching times (t) of 4, 6, 8 and 12 hours, respectively. It is found from the plot that as etching time increases, the pits of lower Z fragments appear. For t = 20 hours 11 projectile fragments of $^{84}_{36}$Kr were found the lowest of which is Mn (Z = 25).

The measured minor axis mean diameters of the projectile along with their fragments are plotted as a linear function of Z for etching times t = 4, 6, 8, 12 and 20 hrs have been displayed in Figure 2. The quantity "$\delta D / \delta Z$", is estimated for different etching times and are displayed in the figure. It is found that the abovesaid quantity increases systematically with etching time except for t = 4 hrs. It indicates the fact that the charge resolution decreases with etching time.

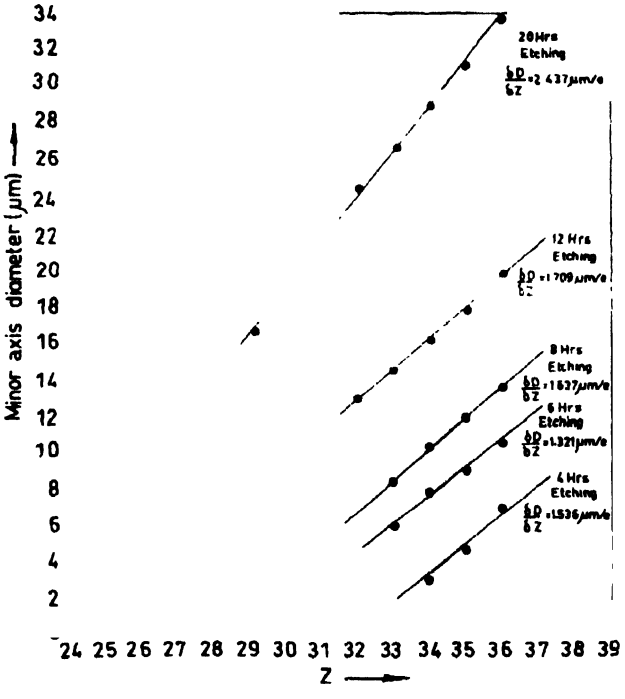

Figure 2. Mean diameters of the Kr fragments plotted as functions of nuclei charges.

Table 1 summarizes the parameters for estimation of charge resolution σ_z along with the charge resolution itself. σ_D is the standard deviation of the gaussian curve fitted to the peak corresponding to the projectile. From Table 1, it is seen that no remarkable change in the charge resolution of the detector has been found for this long hour (20 hrs) etched data in comparison to our earlier observations on short hour etched cases. But, this long hour etching added a number of more projectile fragments which were not revealed previously by short hour etching.

Table 1. The parametric values of σ_D(μm), $\delta D/\delta Z$ (μm/e) and σ_Z(e) as functions of etching time t (hrs).

t	4	6	8	12	20 (h)
σ_D	0.34	0.25	0.25	0.34	0.63 (μm)
$\frac{\delta D}{\delta Z}$	1.54	1.32	1 64	1.74	2 44 (μm/e)
σ_Z	0.22	0.19	0.15	0.20	0.26 e

The estimated charge response V_T / V_G for different etching time t (hrs) is shown in Figure 3. The charge response is found to fall exponentially with etching time as follows

$$V_T / V_G = 33.8136 \exp(-0.0200177t) \quad (1)$$

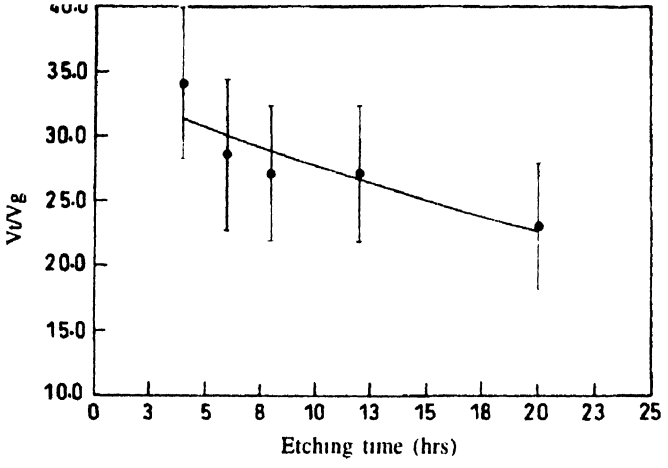

Figure 3. The estimated ratio of the track etch rate to bulk etch rate (V_t / V_G) displayed as a function of etching time t (hrs) Full line is the fit to data after relation (1) as described in the text.

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